BELLCOMM, INC.

SUBJECT: Oral Report by Bell Telephone Laboratories on the Addition of 4-Wire Circuits To The Operational Intercommunication System at KSC
Case 320

DATE: May 15, 1967

FROM: J. J. Hibbert
G. H. Speake

MEMORANDUM FOR FILE

Introduction

On May 3, 1967, a meeting was held at Bell Telephone Laboratories, Holmdel, New Jersey, at which BTL reviewed the results of their investigation of methods of obtaining one or more 4-wire circuits in the user terminals of the Operational Intercommunication System OIS(A) used at Kennedy Space Center (KSC). Represenatives of KSC, NASA Headquarters, MSC, GSFC, MSFC, Bellcomm, and BTL were present at the meeting. Representatives of two support contractors for KSC; namely, General Electric and RCA, also participated. The list of names of the conferees is given in Attachment D.

In addition to the discussion of the 4-wire circuits, BTL also reviewed their measurements of the several versions of the headset transmitters, headset receivers and the amplifiers used in the OIS. The third general topic reviewed briefly was the use of Voice Operated (VOX) Switches and their potential problems.

After the formal presentation, the visitors witnessed laboratory demonstrations of (1) a 4-wire modification of the OIS-A 2-wire system, including a comparison of its performance with different cable and user loading and (2) the performance of non-noise cancelling headset transmitters and noise-cancelling transmitters (like those used with the OIS) in a simulated noisy environment.

Mr. T. H. Thompson opened the meeting with remarks on the developments that led to the work at BTL. In summary; at a meeting held at NASA Headquarters on April 3, 1967, Bellcomm was asked by the Apollo Program Director to determine a means of providing 4-wire communications for a small number of critical OIS conference loops. He also requested that the number of such critical loops and the appearances on each loop be identified by the missions operations personnel at KSC and MSC. It was intended that these critical circuits should be made 4-wire rather than the present 2-wire because of the Apollo and Gemini experience

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X6 (NASA-CR-154660) ORAL REPORT BY BELL TELEPHONE LABORATORIES ON THE ADDITION OF 4-WIRE CIRCUITS TO THE OPERATIONAL INTERCOMMUNICATION SYSTEM AT KSC (Bellcomm, Inc.) 42 p

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Figure 1 indicates the critical circuits that were identified by KSC/MSC as of April 19, 1967, and were thus candidiates for the 4-wire modification. Mr. J. J. Hibbert added that Mr. R. Harrington of KSC had reported that the results of a meeting on May 2, 1967, between KSC and MSC personnel had deleted the requirement for the Launch Vehicle Test Conductor Loop (Black I) to go to the Mission Control Center at Houston. Instead a new critical OIS loop (Yellow X) with only a few users would be implemented to link the launch vehicle systems people at MCC-H with their counterparts in CIF and the Launch Complexes. The requirement for KSC personnel at the Central Instrumentation Facility to talk on the Black I loop has not been resolved, but if this requirement should be deleted, it would not be necessary to convert the Black I loop to the 4-wire configuration.

Using the numbers given in Figure 1, about 1500 OIS user terminals would require one 4-wire circuit; and of these 1500, about 100 would need two 4-wire circuits. Only special panels would require more than two 4-wire circuits. For these reasons, BTL was asked to determine the means by which existing OIS terminals could be reliably and economically converted to the 4-wire configuration for (a) one circuit and (b) two circuits of the 21 OIS circuits that appear at the use terminals. They were also asked to investigate the use of existing and proposed OIS amplifiers and headsets in the modification.

A summary of the reported major findings of the BTL investigation is given below. Details of these studies and the vu-graphs used in the presentations are attached. (Attachments A, B, and C)

I <u>Transmitters and Receivers</u> (Mr. Norwood G. Long, BTL)

Mr. Long discussed the measurements that had been made on the five sample headsets that BTL had received from KSC. The efficiency of the transmitters of these headsets, which were of the noise-cancelling type, was low. Two of the transmitters were 13 dB lower and two were 6 dB lower in output than a microphone transmitter Mr. Long had obtained from the Roanwell Company. This unit, of the noise-cancelling variety, was interchangable with those in the headsets and was available as Roanwell Part #10850. Mr. Long also noted that there was a wide variation in the performance of the individual transmitters of the order of 7 dB.

The frequency response of the transmitters was similar to those used in telephone applications and was compatible with the published response curves. For a fixed acoustical input, the electrical output increases monotonically by 15 dB from 100 Hz to about 5,000 Hz and then decreased. Mr. Long also noted that utilization of the noise cancelling microphone is not advisable unless the signal to noise ratio is less than 12 dB or the total acoustic noise level exceeds about 75 dB RAP (Reference Acoustical Power relative to 10^{-16} watts).

[redacted]

The frequency response of the receiver in the headsets did depart markedly from those used in telephone applications. In particular, four of the five samples indicated a peak of response at 400 Hz and a negative slope from this peak until at about 3 kHz; they were about 10 dB below the output level at 400 Hz and then increased in response from 3kHz to about 6kHz before dropping. The frequency response of a telephone receiver is flat to within + 2 dB from 250 Hz to 3kHz. There is no significant contribution to the intelligibility of speech if the transmission band is made greater than this even though the quality may be more pleasing with a greater bandwidth.

Three things were stated to be undesirable with the present headset receiver response: (1) the negative slope in output between 400 Hz and 3000 Hz which would result in lower speech intelligibility than could be obtained with a flat response receiver, (2) the high frequency response above 3.0 kHz which would emphasize the noise without adding to the voice intelligibility, and (3) similarly, at the low end of the frequency range, the high response would not discriminate against power-line frequencies and their harmonics.

Although the frequency response of these headset receivers were consonant with the specifications, the military specifications for the receivers had been written to cover a number of receivers, including those used in high altitude military aircraft. Thus, it was stated that the negative slope in response between 400Hz and 3000 Hz would be flattened if these receivers were operated at 35,000 feet in unpressurized aircraft. It was noted by Mr. Long that a flat frequency response in the headset receivers between 250 and 3000 Hz with a rapid roll-off at either end would be more appropriate to the OIS.

II <u>OIS Amplifiers</u> (Mr. Doren Mitchell)

Mr. Mitchell reviewed the frequency response, automatic gain control (AGC) and linearity of the amplifiers used for transmission and reception in the OIS terminal boxes. Two versions of transmitting amplifiers were measured (1) the present system and (2) the modification that had been proposed in 1966 for improving the level and frequency performance of the OIS. Mr. Mitchell indicated that the present transmitting amplifier could use an additional 10 dB gain (although this gain could also be obtained from a more efficient headset transmitter), and that the AGC in the present transmission amplifier is not needed. The modified transmitting amplifier has a peak in frequency response at 8 kHz which is undesirable; a roll-off in frequency response starting at 3 kHz would be better. It was also suggested that the modified amplifier could use some additional gain.

The OIS terminal receiving amplifiers have too broad a frequency response (0.1 - 8 kHz); it would be desirable to reduce the pass bandwidth to 0.25 - 3.0 kHz. In addition, the AGC in the receiving amplifier now has a slow attack time (50 millisec); it would be better to reduce it to about 10 millisec.

Mr. Mitchell also has noted that the design of the present system results in operation near the knee of the AGC response curve of the receiver amplifier. This means that the average talker drives the receiving amplifier to the flat portion of the response curve. A better design, in Mr. Mitchell's opinion, would be to operate on the linear portion of the response curve so that only a very strong talker would cause the receiving amplifier to be operated in the flattened portion of the curve. This design would reduce the noise and distortion in the system. No change would be needed in amplifier design; though the transmitting bus impedance should be reduced to approximately 100 ohms rather than 600 ohms.

III <u>Addition of 4-Wire Circuits to OIS</u> (Mr. H. J. Michael)

Mr. Michael reviewed a method of adding either one or more 4-wire circuits to the existing 2-wire OIS(A) system. This change would eliminate the use of Voice Operated Switches (VOX) in the conference loops and prevent the occurrence of (1) "echoes" (2) "lockup" (3) "double talking" which have been noted in these circuits previously. The method (described in detail in the attached Appendix) employs relays in the present OIS terminal units to switch from the 2-wire mode employed for most of the loops to the 4-wire mode for 1 or 2 loops. When the user turns to the 4-wire loop, the switch connection activates relays which connect the 4-wire circuits to the headset. The design of the 4-wire system is a so-called "busbar" design with a low characteristic impedance of the order of 1 ohm. Diagrams of this 4-wire modification are shown in Figures 2 and 3.

BTL investigated the cable distribution layout employed at Complex 34 and 37, and believes that this type of 4-wire system is applicable to the existing cable plant. Isolation resistors are suggested in the 4-wire distribution to prevent malfunctions on one branch from affecting the performance on the other branches. The two pairs required for the 4-wire circuits are obtained by using the pair for the present 2-wire loop for the receiving leg and using the pair from another unused 2-wire loop for the transmitting leg.

The equipment added to the terminal box would consist of two relays and two coils for one 4-wire circuit or three relays and three coils for two 4-wire circuits. Some diodes for reducing relay interference and condensers for DC blocking would also be required. Mr. Michael showed the samples of the relays and coils that appeared appropriate for this use.

In the discussion of the relays, Mr. A. Kempson (KSC) questioned the performance of such relays in a vibration environment such as that in the Block House when a launch takes place. Mr. Kempson volunteered to obtain vibration data so that the relay performance in such environment could be determined.

IV <u>Discussion of Voice Operated Devices</u> (Mr. D. Mitchell)

Mr. Mitchell warned the audience that Voice Operated Devices should only be employed when they provide the only means of obtaining the desired performance. He then presented a review of some of the features and difficulties of such devices, which was extracted from a talk to be presented at the IEEE Meeting in Minneapolis in June.

Unfortunately, there is no easy way to tie a 2-wire system to a 4-wire system without the use of voice operated switches if the number of users of the conference loop changes with time. If the impedance level and the number of users could be held constant, a passive hybrid equivalent to the VOX device could be employed. Unfortunately, with the number of conferees on the OIS loops and their variability in appearing on these voice loops, it does not appear feasible to employ passive hybrids.

<u>Other Considerations</u>

In answer to a question by Mr. W. Parsons as to methods of improving the performance of the OIS circuits that would remain 2-wire, it was pointed out that BTL had not been asked to address that question in detail and could only answer the question in part. Specifically, the suggested improvement in headset transmitters and headset receivers could be beneficial to both 4-wire and 2-wire systems. Thus it was the conviction of the BTL speakers that a more efficient transmitter and a receiver of somewhat higher efficiency and flattened frequency response would make a significant improvement in the performance of the present OIS.

Summary

A feasible method for obtaining one or two 4-wire circuits for the primarily 2-wire OIS system at KSC has been devised by BTL. The unresolved questions are: (1) whether the existing AIA amplifier could be used as the low impedance 4-wire amplifier, and (2) whether the relay used in the 4-wire modification will continue to work in the vibration environment that the Block House experiences during launch. BTL plans to determine the answers to these two questions.

The question of improving the OIS 2-wire circuits which go off Complex in both the transmitting and receiving modes was not asked of BTL in its initial work assignment, and would require additional effort by them if a complete answer were desired.

J. J. Hibbert

G. H. Speake

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Attachments A-D

APPEARANCES AT KSC
*LAUNCH CRITICAL OIS LOOPS

	COMPLEX 34	COMPLEX 37	KSC OFF COMPLEX
L/V TEST CONDUCTOR (BLACK 1)	350	350	150
LAUNCH OPERATIONS MANAGER (BLACK 2)	100	100	10
S/C TEST CONDUCTOR (BLACK 3)	250	250	10

	TOTAL
AERO MED (GREEN 13)	12
SYSTEM MONITOR (GREEN X)	6
FLIGHT DIRECTOR	10
MISSION DIRECTOR	12
AIR GROUND #1	5
AIR GROUND #2	5
RECOVERY COORDINATION	3
PUBLIC INFORMATION OFFICE	3

* AS OF APRIL 19, 1967

FIGURE 1

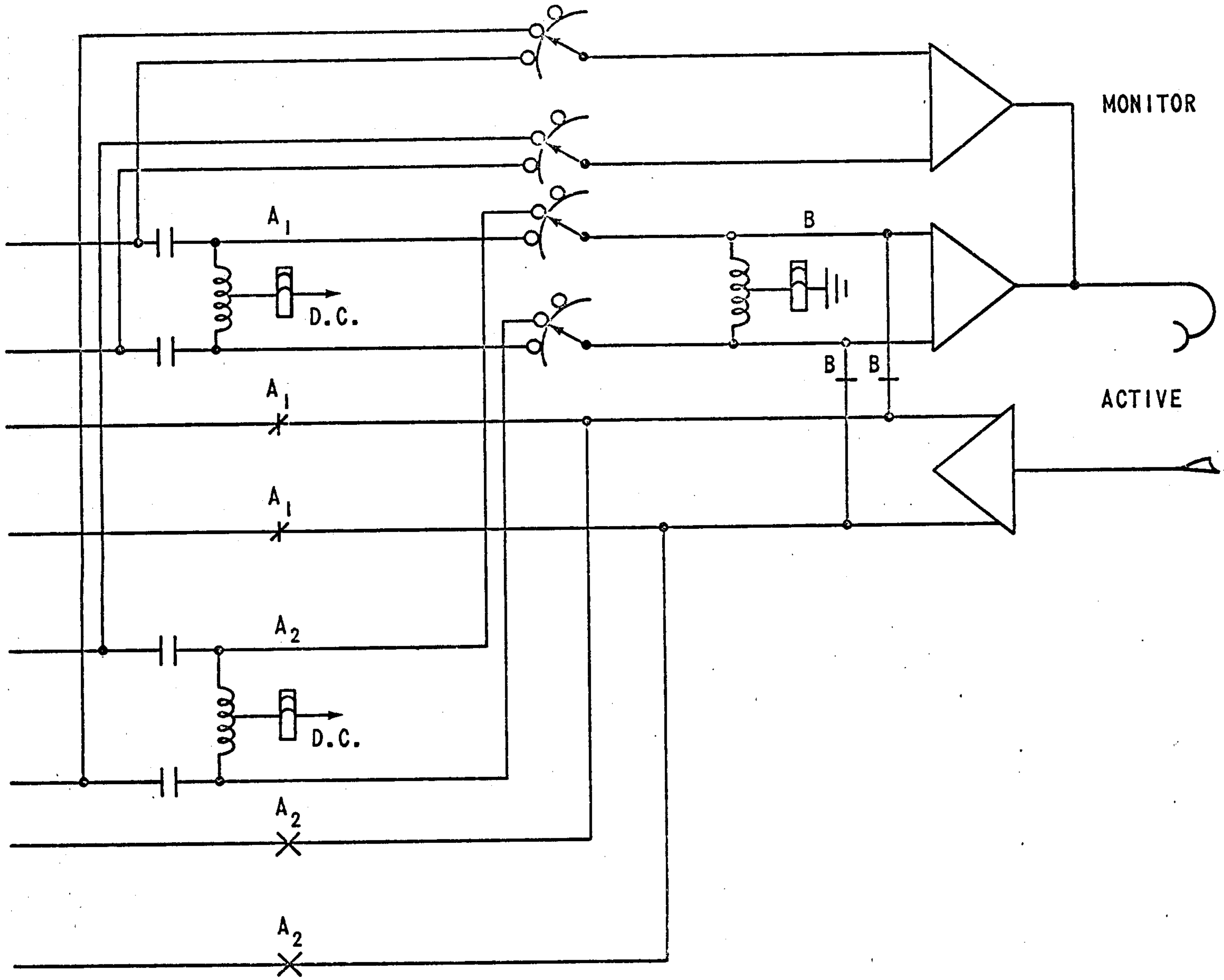
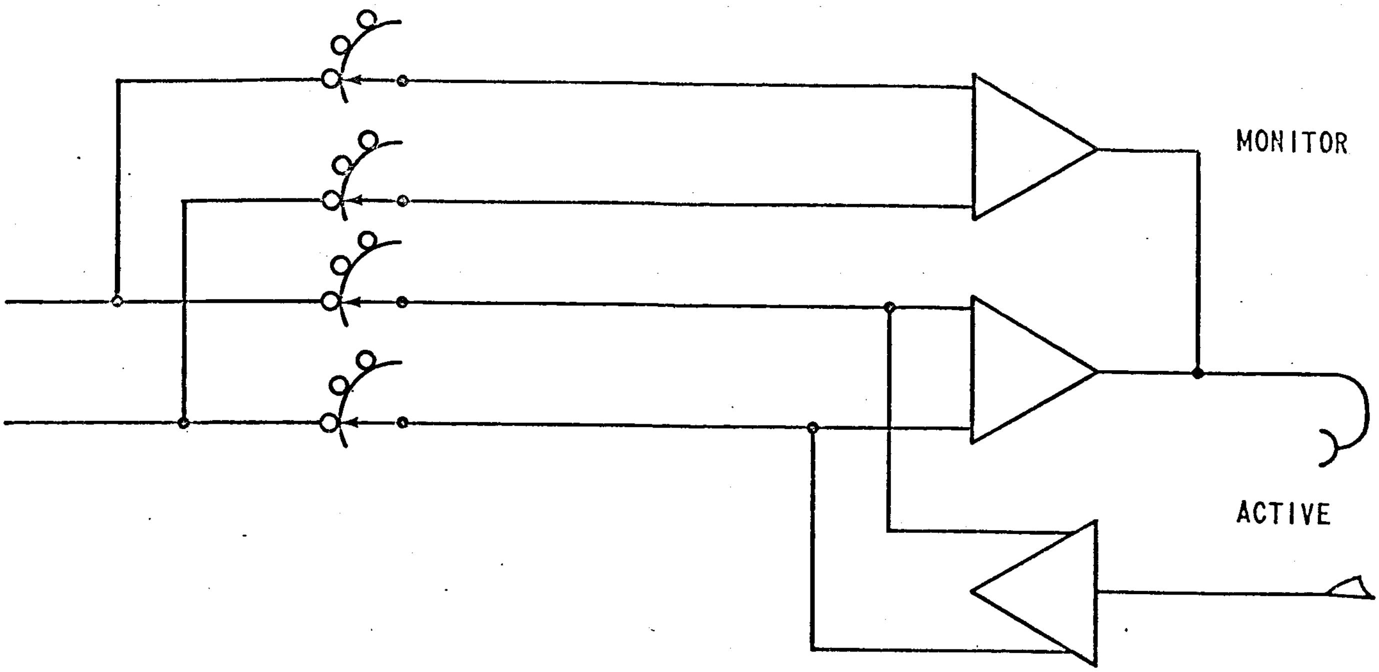
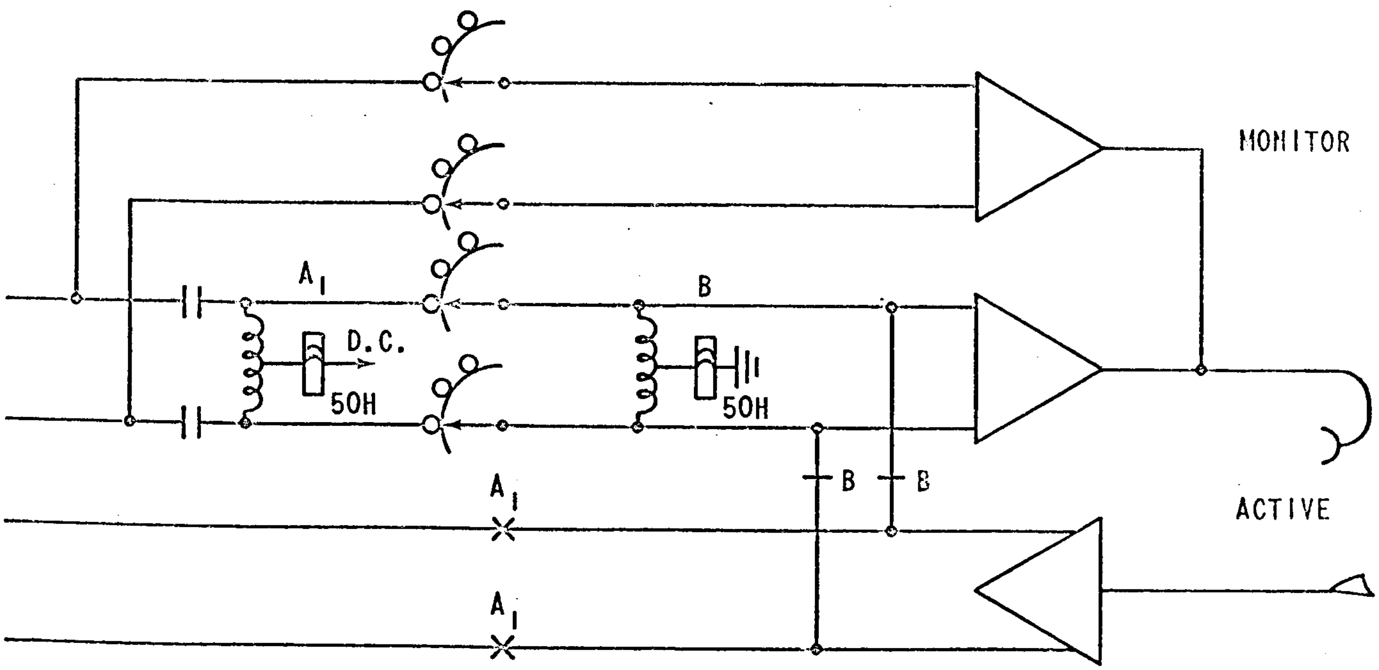


FIGURE 2 - MODIFICATION FOR TWO 4-WIRE CIRCUITS



EXISTING 2-WIRE



ONE 4-WIRE

FIGURE 3 - MODIFICATION FOR ONE 4-WIRE CIRCUIT

Evaluation of KSC Headsets.

May 15, 1967

Five samples of the headsets in use at KSC have been tested. The results of these tests are summarized below. Most of this material was presented to KSC and associated personnel on May 3, 1967.

1. Receivers: Fig. 1 shows the frequency response of selected receivers. They show two serious deficiencies: a dip between 500 Hz and 3 kHz, and large peaks at 5 to 6 kHz. The dip causes a loss in intelligibility; the peaks add very little to intelligibility and over-emphasize sibilants and plosives, causing listener fatigue. Limited listening tests have indicated that of the two effects, the high frequency peaks are more disturbing.

In general, between 90 to 95% of the sentence intelligibility is contained below 3 kHz. If a wider bandwidth is used to gain naturalness and slight extra articulation it must be coupled with a smooth, wide dynamic range transmission system. In the expected use, the wider undulating bandwidth of present receivers emphasizes noise and distortion without improving level or intelligibility. The performance would be improved if new transducers were employed with a flat bandwidth from (about) 200 c/s to 3200 c/s. As shown in Fig. 2, transducers with this response are well within present design capability. There is some evidence that the jagged frequency response of present units may be a consequence of the ability to work at low pressures, up to 35,000 feet of altitude.

The efficiency of the present receivers is much lower than can be obtained. A unit of about the same size and weight as present receivers with the desired frequency characteristics is available commercially with an improvement in efficiency over KSC receivers of between 10 and 15 dB (see Model, below). As discussed below, gain in the transducers has the advantage over increased amplifier gain of stability and low noise. Increased transducer gain (microphone and receiver) could be used to lower bus impedance on two wire conferences below the present 600 ohms, to improve bandwidth (intelligibility) and signal level with large conferences.

2. Microphones: Frequency measurements on the dynamic noise cancellation microphones are shown in Fig. 3. They all show a rising characteristic from (roughly) 200 Hz to 5 kHz. This is usual in such microphones for much the same reason as pre-emphasis is employed in the record industry; to gain

signal-to-noise advantage at those frequencies most likely to suffer loss in the transmission system. As shown in Fig. 4, carbon microphones in use in the Bell System exhibit a similar characteristic. Any new microphone employed should have a rising characteristic, although if receivers restricted to 3 kHz are employed pre-emphasis in the microphone beyond this point will have little significance.

The microphones tested were deficient in two ways: in output level and in variation from unit to unit. A spread of 10 dB was observed among the 4 noise cancellation samples, and all were several (10-30) dB below other dynamic units available. Some of this is due to noise cancellation, as discussed below.

Because of the large number of users, amplifier noise can be significant with very low level microphones. The signal to noise ratio can be improved if more efficient units are employed. As shown in Fig. 5, a physically interchangeable microphone is available with 10 - 15 dB more gain than the lowest level KSC unit tested.

The value of noise cancellation in a new microphone must be weighed against the inherent penalties of lower output and increased penalty with misuse. In limited tests one of the KSC noise cancellation microphones showed a 6 dB greater spread in output with position than a noncancellation microphone. Since the cancellation is achieved by providing a sound path to the diaphragm through both the front and the back of the microphone, there is some possibility of pick-up of very near interferring talks from the back of the unit. For talkers and noise sources at some distance from the unit cancellations on the order of 10 - 15 dB are possible below (about) 1.5 kHz. Above 1.5 kHz almost no cancellation occurs.

Attempts to measure the subjective benefit of cancellation in a high noise field have not been fully satisfactory. It appears, however, that for noise and background fields below 75 - 85 dB, which are levels comparable to those in a small factory, noise cancellation is not necessary. The value of noise cancellation is partly determined by number of simultaneous users; if the number of simultaneously active microphones can be kept to less than 50 or so, the signal-to-noise ratio at the ear of the listener would probably be excellent without cancellation. If, however, high noise levels and large number of simultaneously active users are present, cancellation may be useful. The unit shown in Figure 5 is a noise cancellation unit, as discussed below.

3. Model: Discussions with one manufacturer, the Roanwell Corporation, have disclosed that microphone-receiver units are available with improved efficiency and frequency response. Receiver unit is a new design coded RE300. Microphone is coded 108500. Receiver impedance is 20 ohms, and transmitter impedance is 5 ohms, as in the KSC units. Plug, switch format, and physical dimensions are identical with KSC units. A comparison between the headsets is given below:

	Receiver		Microphone	
	KSC	Model	KSC	Model
Frequency Response	200-6 kHz Undulating	200-3.2 kHz Flat	300-5 kHz Rising	Same
Increased Gain		+10 - +15 dB		+6 - + 15 dB
Noise Cancellation			10-15 dB	8-10 dB

All of the above characteristics are approximate, since they are based on measurements with limited samples or verbal descriptions. Three of the headsets have been promised for (about) May 24, 1967. These units will then be compared with the present samples to determine final characteristics. A study is in progress to determine the effect of improved headsets on transmission quality.

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FIGURE 1

RELATIVE RESPONSE OF NASA HEADSET RECEIVERS

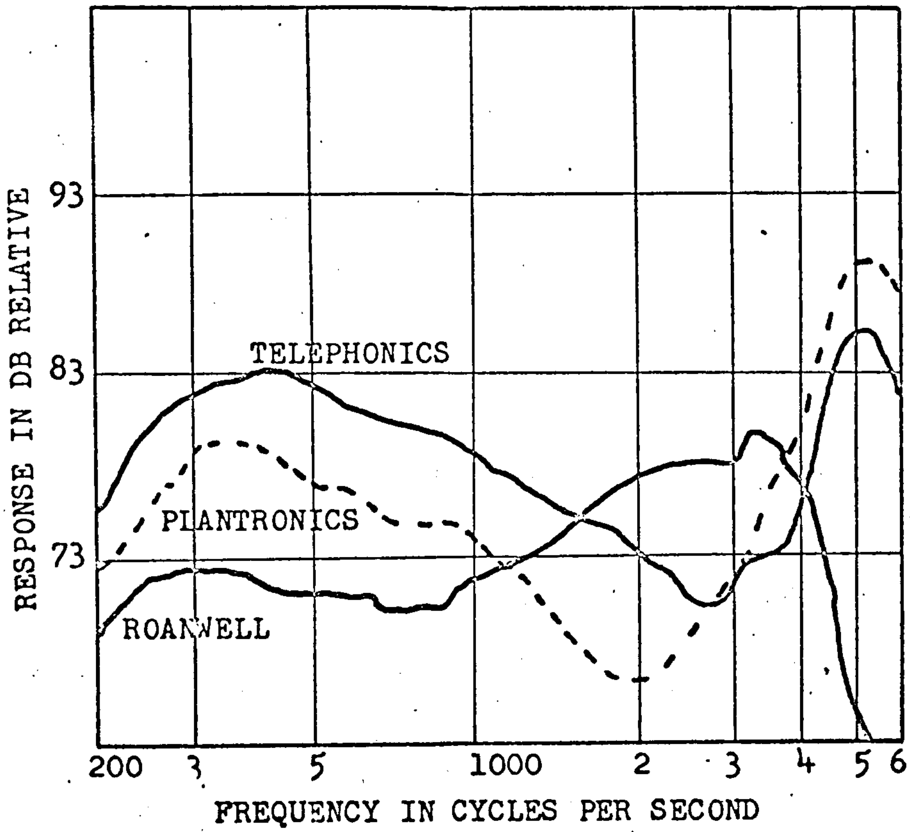


FIGURE 2

RESPONSE OF BTL 52-HEADSET RECEIVER

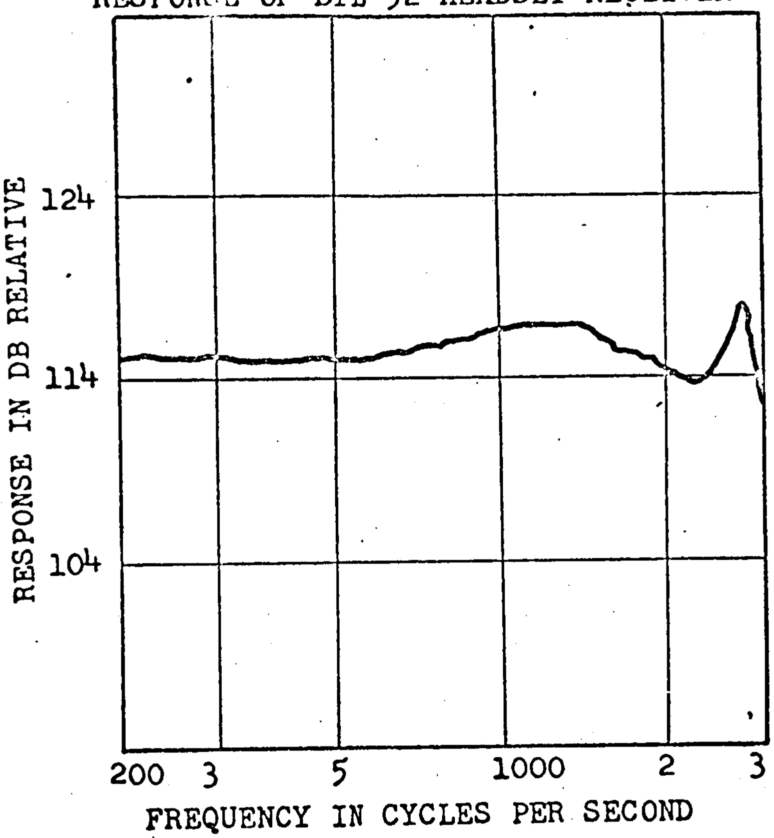


FIGURE #3

RELATIVE RESPONSE OF NASA HEADSET TRANSMITTERS

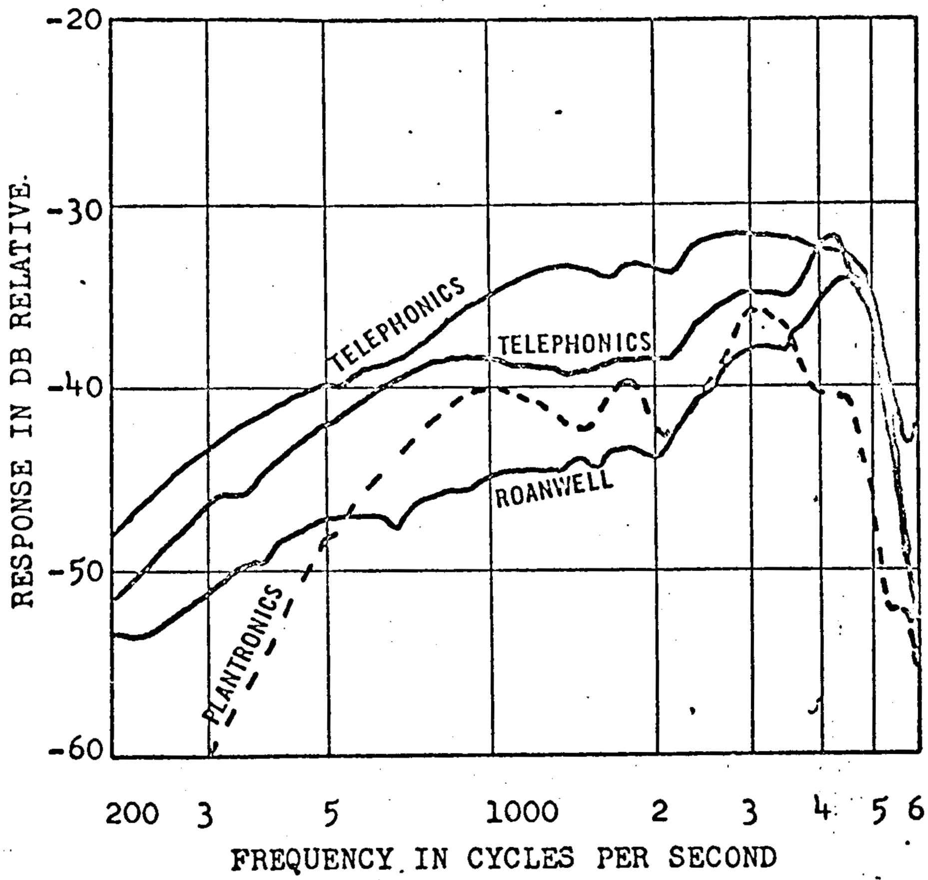


FIGURE 4

RESPONSE OF BTL 52-TYPE HEADSET TRANSMITTER

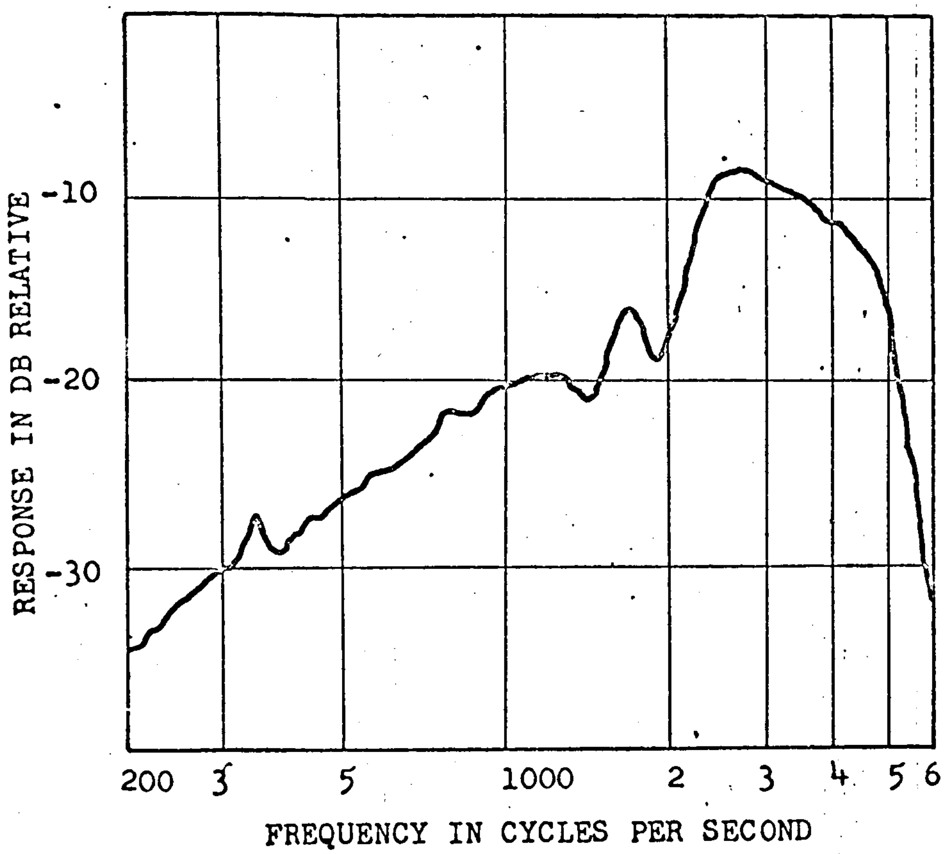
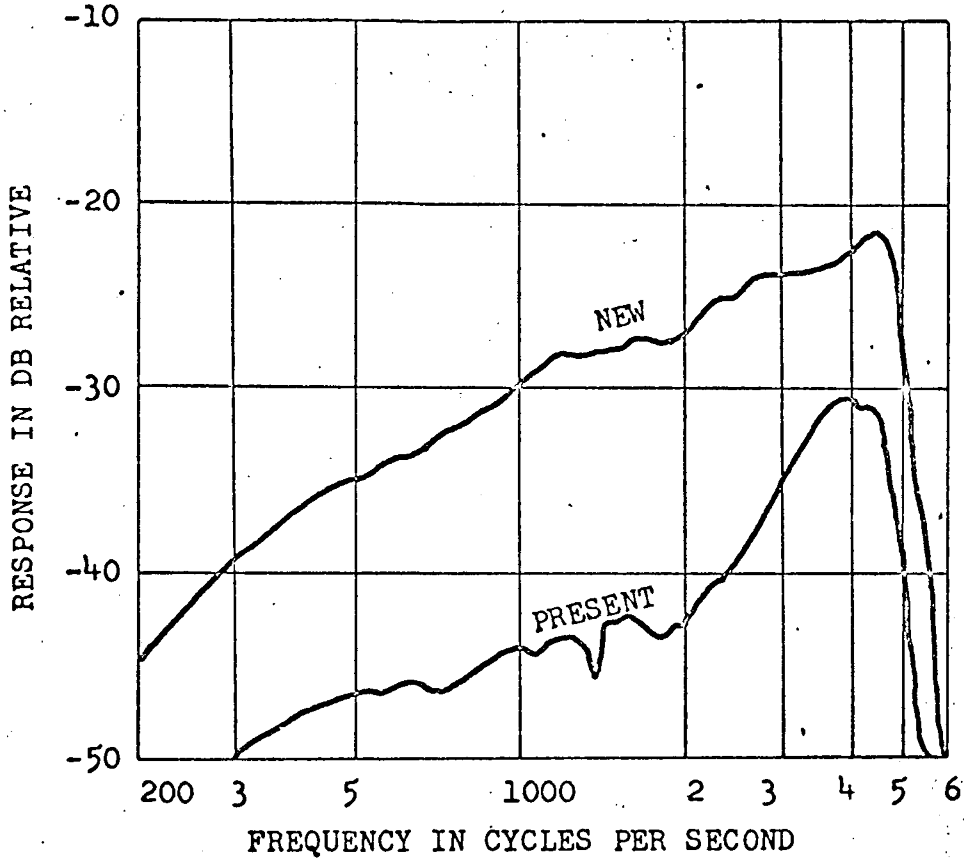


FIGURE 5

COMPARISON OF ROANWELL TRANSMITTERS



ATTACHMENT B

May 15, 1967

Amplifier Characteristics and
Discussion with NASA Representatives

This memorandum summarizes measurements made on the amplifiers and voice switching arrangements in the Cape Kennedy conference system, and discussion of these topics with NASA representatives on May 3, 1967.

In the discussion, Mr. Mitchell first briefly outlined operation of the voice switching arrangements known as VOX in the present system. This is shown in Figure 1. It was pointed out that this type of voice switching is subject to four basic difficulties which can occur under circumstances of improper usage or high noise.

The first is clipping of weaker portions of speech if someone talks too weakly. The second is false operation of the control P by echo if any echo exists in the line as indicated. This results in severe mutilation of speech, making it essentially unintelligible. The third difficulty can occur due to noise, for instance, from subset X, which can effectively lock up VOX 2, thus preventing any one on the control building setup from getting out. A fourth difficulty occurs if someone on the launch complex talks at the same time as someone at the control tower. In this case only one can get through at a time, and it is actually possible for speech to occur for several seconds without either one realizing that two people are talking. Those present agreed that these were serious difficulties and that the VOX should be eliminated.

A summary of the status of the present amplifiers was then given as shown in Figure 1A. The point was made that the amplifiers leave something to be desired in several respects, but they are generally usable, particularly if microphones with about 10 dB more efficiency could be obtained. Detailed measurements were then presented which will be described later.

In the afternoon, Mr. Mitchell spoke briefly about some of the problems in setting up reasonably satisfactory 2-wire conference systems. This material is part of a paper to be presented to the IEEE Convention this coming June.*

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*General Transmission Considerations in Telephone Conference Systems - Proposed IEEE Paper, by D. Mitchell.

Figure 6 was first discussed briefly which indicates that the combination of multiple echo and multiple sources of noise produce a serious problem in toll conference calls. It was pointed out that this had led to the use of voice switching because in the present telephone network there is no way to control the echo and noise in any other way.

Figure 7 was then discussed which shows the type of voice switching we use. It was emphasized that we have added several features quite different from the earlier type of voice switching the the VOX to minimize the undesirable effects of voice switching. These include switching minimum loss (about 15 dB), differential breakin using the SG (switch-guard), and a noise guard device N.

It was emphasized also that although there are considerable variations in the telephone network we know their values reasonably well and can take account of them.

Figure 8 was then shown to bring out the differences between the NASA conference problem and our toll telephone problem. The main difficulty in the NASA problem is that neither losses or return losses are known very accurately, and probably have large variations. It was stated that it is probably possible to operate moderate sized systems 2-wire in a reasonably satisfactory manner if it is not necessary to connect these systems to points outside the immediate vicinity of Cape Kennedy.

It was emphasized, however, that no firm statement could be made as to just how well a 2-wire system would operate either with or without some new features such as improved voice switching, unless considerably better information about transmission parameters was available.

Detailed Measurements

Figure 2 shows the frequency response of a microphone amplifier. This includes a typical present-type amplifier and also the proposed GE amplifier.* These measurements were made by producing known constant voltage effectively in series from a 5 ohm source for the input and measuring the output produced in 600 ohms.

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*At least three amplifiers of each type were tested.

Note that our measurements indicated a slightly different frequency characteristic than that stated in NASA-KF-652. The actual measured characteristic of the present amplifier seems quite favorable for this use, and the roll-off at 300 cycles and 3000 cycles is desirable.

The GE amplifier was actually designed to have a frequency rise to compensate for cabling capacitance loss at the higher frequencies. However, a characteristic more like the one measured in the present amplifier is believed to be better if the amplifier is operated into a 60 ohm bus.

Figure 3 shows the input-output characteristics of the two amplifiers. In this case the measurement on the present amplifier was made with the output connected into 600 ohms, but the measurement on the GE amplifier was made with the output connected into 60 ohms. Our measurements indicated considerably less expansion at low inputs than is stated in NASA-64-KF-652. There is no apparent reason for this difference, but possibly the NASA measurements were made on a different version of the microphone amplifier.

The relatively slight amount of expansion in the microphone amplifier is apparently inherent in the circuit elements and there is no syllabic type expansion as we use in some of our voice switching devices. This was checked by sending pulses of tone into the amplifier and taking oscillograms of the output.

Measurements of the amount of harmonics produced by the present microphone amplifier are summarized in the following table.

Microphone Amplifier - Average of 3 Units

Measured 2nd and 3rd Harmonic Output

In dB Below the Fundamental

Input (1000 Hz)	2nd	3rd
1×10^{-3} volts	31 dB	37 dB
1×10^{-4} volts	47 dB	29 dB
1×10^{-5} volts	43 dB	35 dB

The limiting in the microphone amplifier measured occurs at approximately the same point as shown in NASA-64-KF-652. It was found, however, that the limiting action for high inputs such as 10^{-3} volts required about 80 ms.* There is very little gain decrease for the first 50 ms, and most occurs during the next 30 ms. It was also noted that for inputs greater than 5×10^{-4} volts the output signal would be distorted during the first 40 to 50 ms. This distortion is due to overload in the amplifier and occurs before the AGC circuit can operate.

The recovery time is about 300 to 500 ms after a strong signal is removed. These time constants are reasonably satisfactory, but not ideal. It would be better if the attack time would be about 10 ms, but the recovery time is satisfactory.

The gain of the GE amplifier is about as expected. It is an ordinary amplifier and the upper end of the curve indicates ordinary overloading.

Figure 4 shows the frequency response of the headset amplifier. Here our measured results are very close to NASA-64-KF-653. On the other hand it would be very desirable for this amplifier to roll off below 300 cycles and above 3000 cycles. Energy below 300 cycles may contain undesirable 60 cycle harmonics and does not add to intelligibility. Energy above 3000 cycles also adds very little to intelligibility and may contain high frequency noise.

Figure 5 shows input-output characteristics of the headset amplifier. Here also our measurements indicate considerably less expansion than those shown on NASA-64-KF-653, and are very similar to the measurements for the microphone amplifier. On the other hand, the limiting point or knee of the curve checks rather closely. These measurements were made by producing a known input voltage and measuring the output in dBm into 10 ohms.

It was found that the limiting action for high inputs such as 1×10^{-1} volts required approximately 100 ms. During the first 80 ms, very little gain reduction was observed. Also

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*Test results indicate that limiting action of the microphone amplifier occurs very seldom in the present system.

it was noted that for inputs greater than 1×10^{-1} volts, the output signal at the headset amplifier would be distorted during the first 50 to 80 ms. As in the case of the microphone amplifier this distortion is due to overload in the amplifier and occurs before the AGC circuit can operate. The recovery time after a strong signal is removed is approximately 100 to 300 ms.

We also checked the headset amplifier and determined that it did not have any syllabic expansion. Thus the expansion shown in Figure 5 is apparently inherent in the circuit design.

Harmonics were also measured in this amplifier as summarized on the following table.

Headset Amplifier - Average of 3 Units

Measured 2nd and 3rd Harmonic Output

In dB Below the Fundamental

Input (1000 Hz)	2nd	3rd
2×10^{-1} volts	31 dB	35 dB
5×10^{-2} volts	36 dB	36 dB
1×10^{-2} volts	39 dB	27 dB

As indicated in Figure 5, it is believed that speech volume in the present system ranges from about 2×10^{-2} to 1×10^{-1} volts. The latter is about 10 dB into the limiting region. As discussed in another memorandum*, the performance would be better if the operating point were set about 5 dB below the knee.

D.M.
DM
GPR-MK
GPR

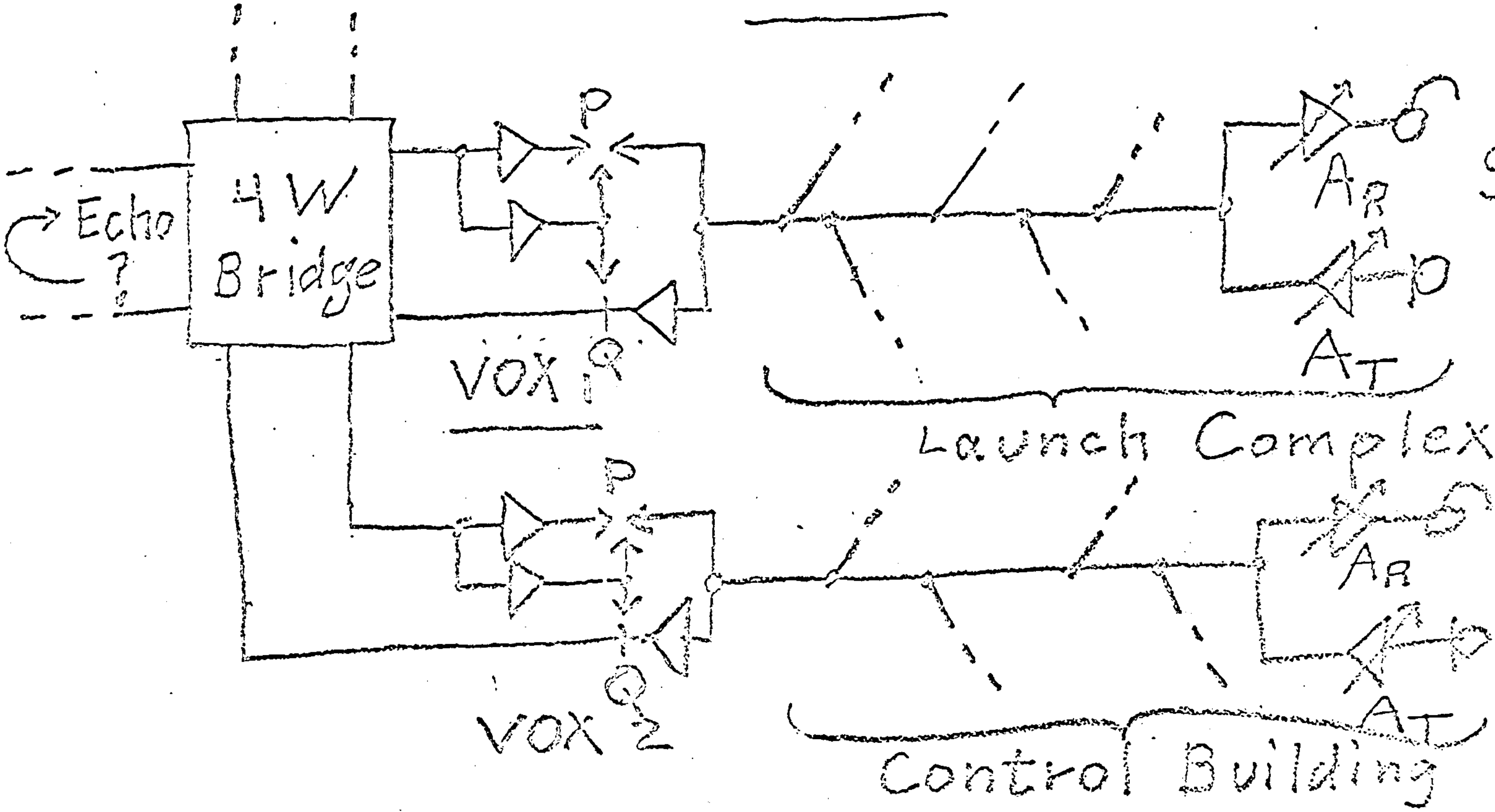
Att.
Figures 1-8

*MFF, "Optimum Operating Point of Receiving Amplifier Volume Limiter for Cape Kennedy Conference System", dated May 9, 1967, by D. Mitchell.

Present 2 Wire Conference System at Cape Kennedy

5/1/67

FIG 1



REVISED MAY 12, 1967

FIG. 1A

CAPE KENNEDY CONFERENCE SYSTEM

SUMMARY OF PRESENT INFORMATION ON AMPLIFIERS

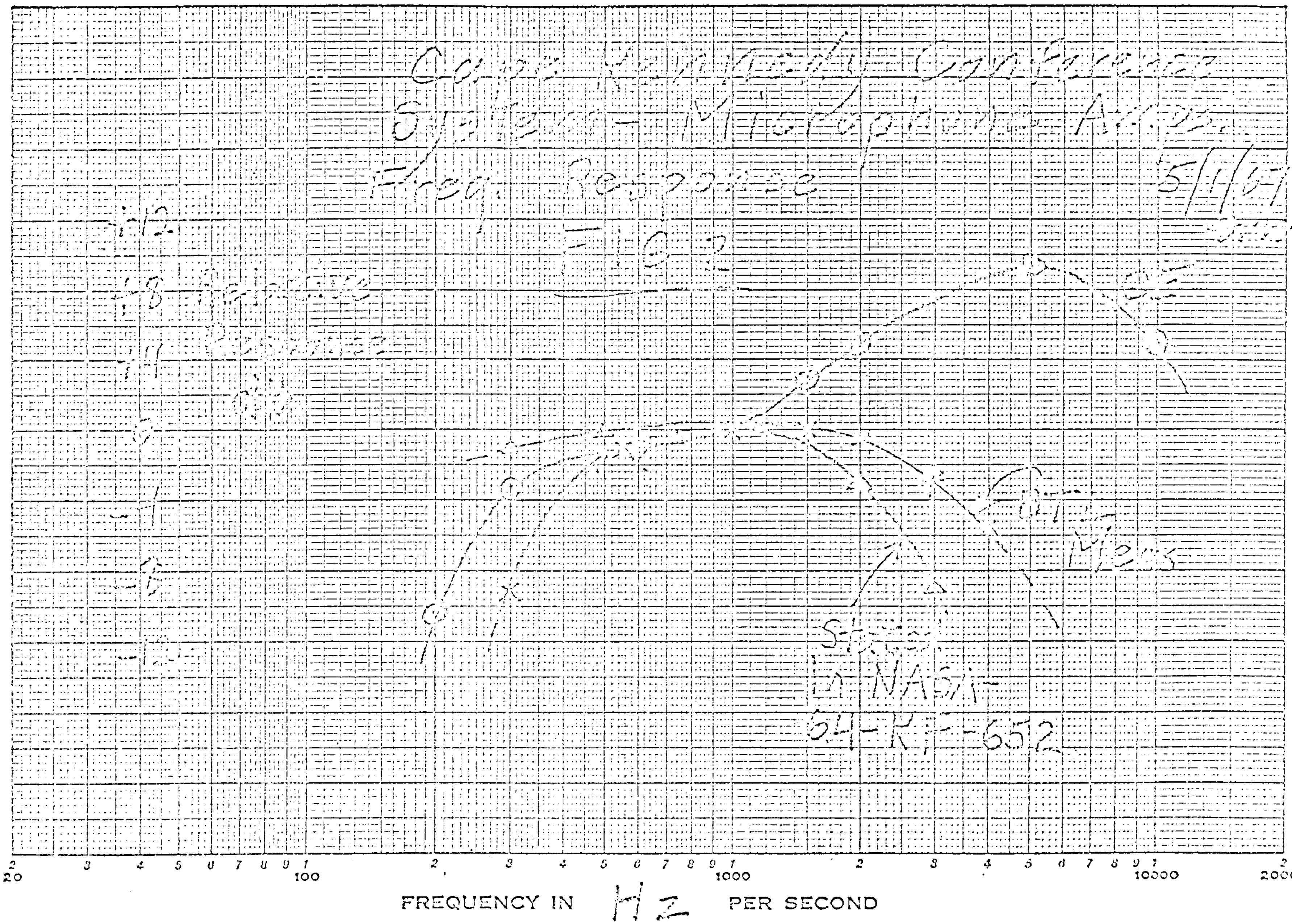
FEATURE	MICROPHONE AMPLIFIER PRESENT	MICROPHONE AMPLIFIER GE	RECEIVING AMPLIFIER
FREQUENCY CHARACTERISTIC			
PRESENT	300-2700 Hz	250-10,000 Hz (8 dB RISE at 8000 Hz)	100-8000 Hz
RECOMMENDED	OK	MAKE FLAT	300-3000 Hz
MAXIMUM GAIN			
PRESENT	USABLE	USABLE	SATISFACTORY
RECOMMENDED	10 dB ADD'L	10 dB ADD'L	
AGC TIME ACTION			
PRESENT	50-80 ms ATTACK* 300-500 ms RECOVERY*	NOT PROVIDED	80-100 ms ATTACK* 100-300 ms RECOVERY*
RECOMMENDED	NOT NEEDED	NOT PROVIDED	IS NEEDED, BUT 10 ms ATTACK IS BETTER
AGC OPERATING POINT (KNEE OF CURVE)	CAN BE MADE SATISFACTORY IF SYSTEM IS PROPERLY LINED UP		
LINEARITY	OK	OK HARMONICS FROM 20-30 dB DOWN	OK
APPROXIMATE SPEECH/NOISE IN dB AT AVERAGE VOLUME	20-40 dB, BUT DEPENDS ON SIZE AND LINE-UP OF SYSTEM	30 (OK)	50 (OK)

*These numbers are slightly different from those presented in an earlier table.

ISSUE | DRAWN | ENGR | TITLE

BELL TELEPHONE LABORATORIES
INCORPORATED

NO. OF SHEETS PER SET | SEE SHEET 1 | SHEET



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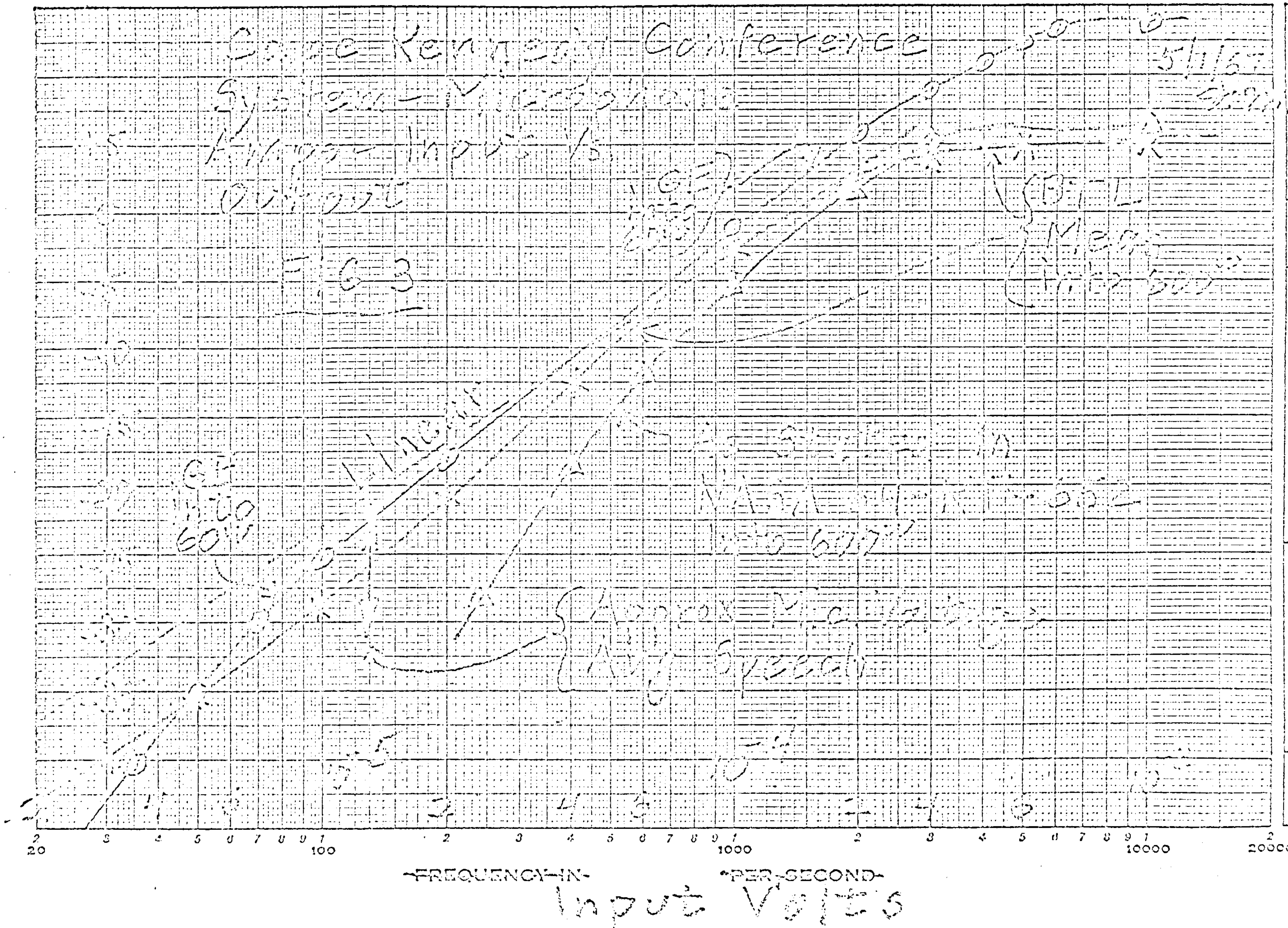

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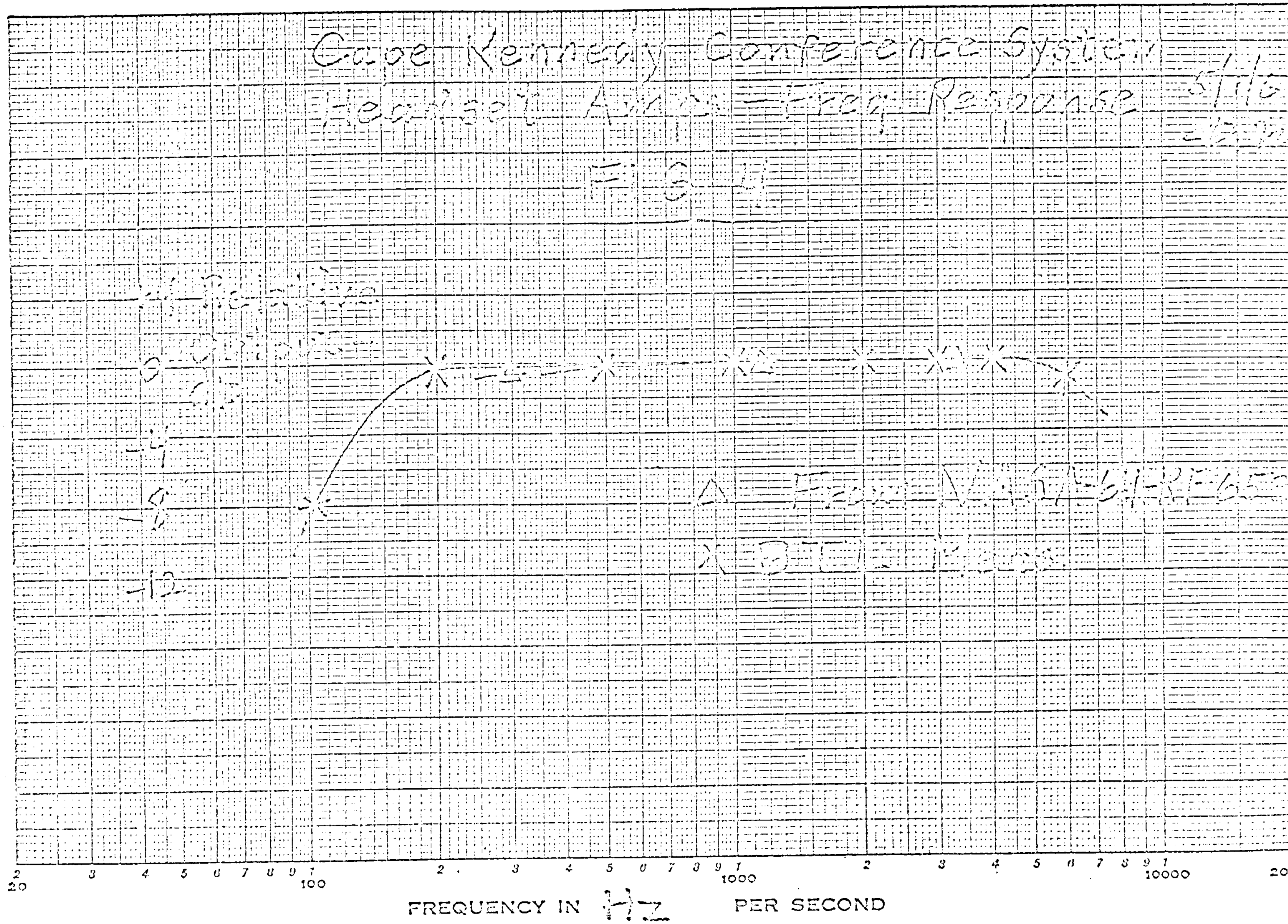

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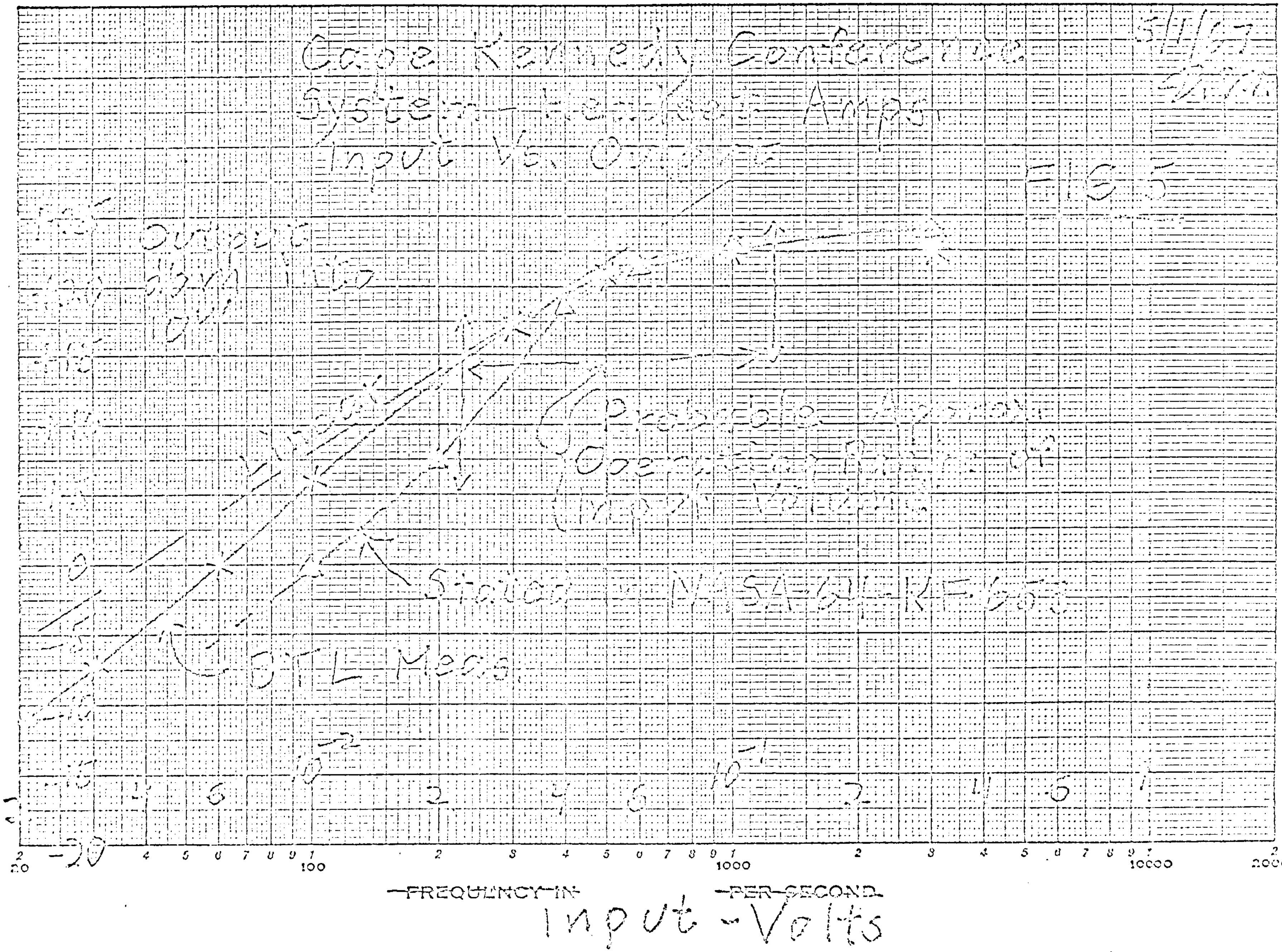

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FIG. 6

TOLL TELEPHONE CONFERENCING TRANSMISSION CONSIDERATIONS

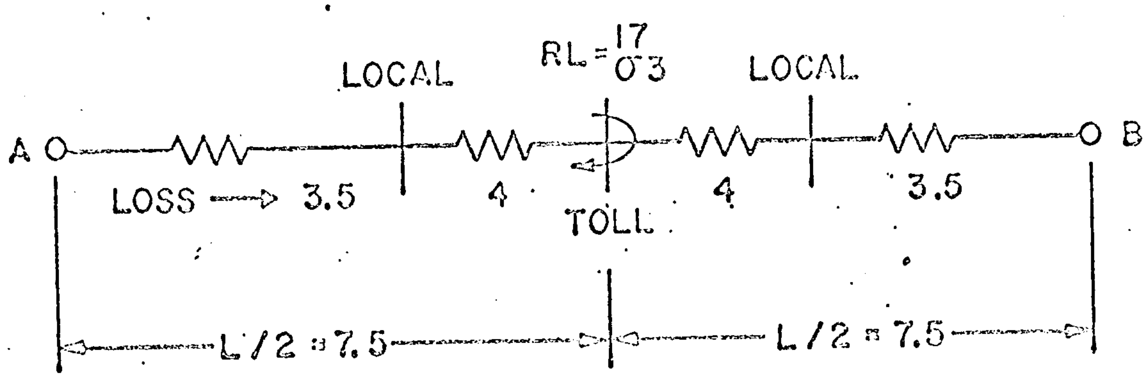


FIG. 6A TYPICAL TOLL CALL

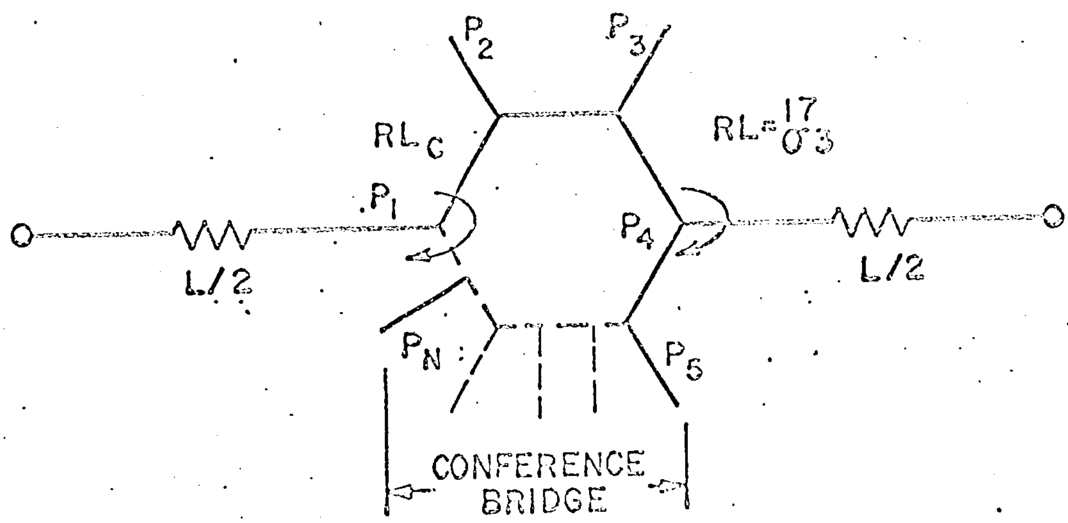
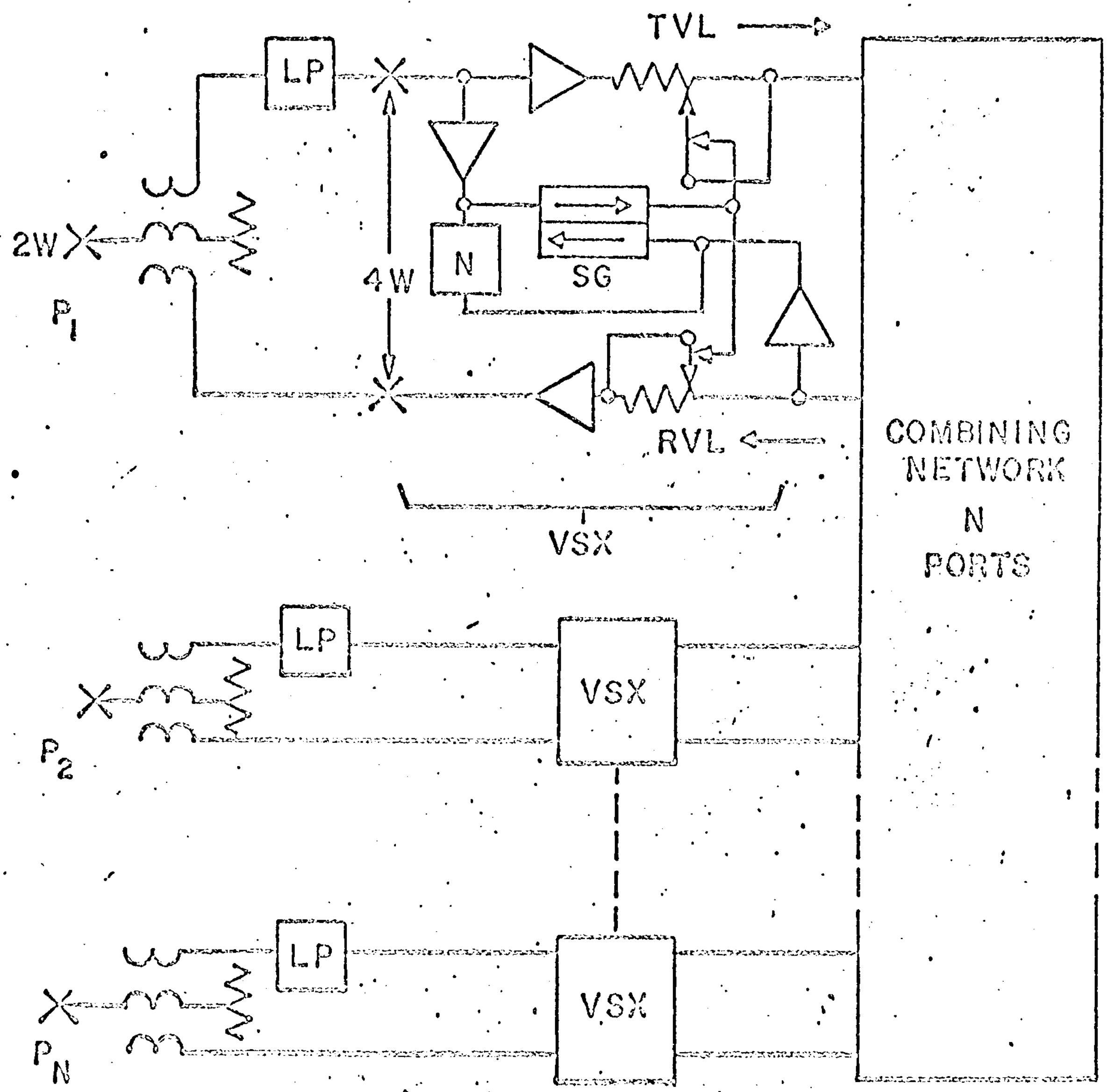


FIG. 6B TOLL CONFERENCE CALL

FIG. 7

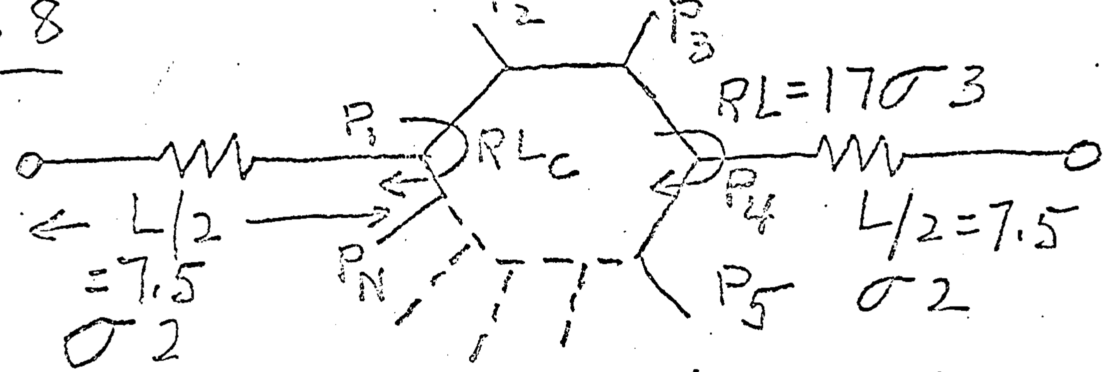
TOLL CONFERENCE WITH N PORTS USING VOICE SWITCHING (VSX)



Comparison of Toll Telephone Conference With NASA Problem

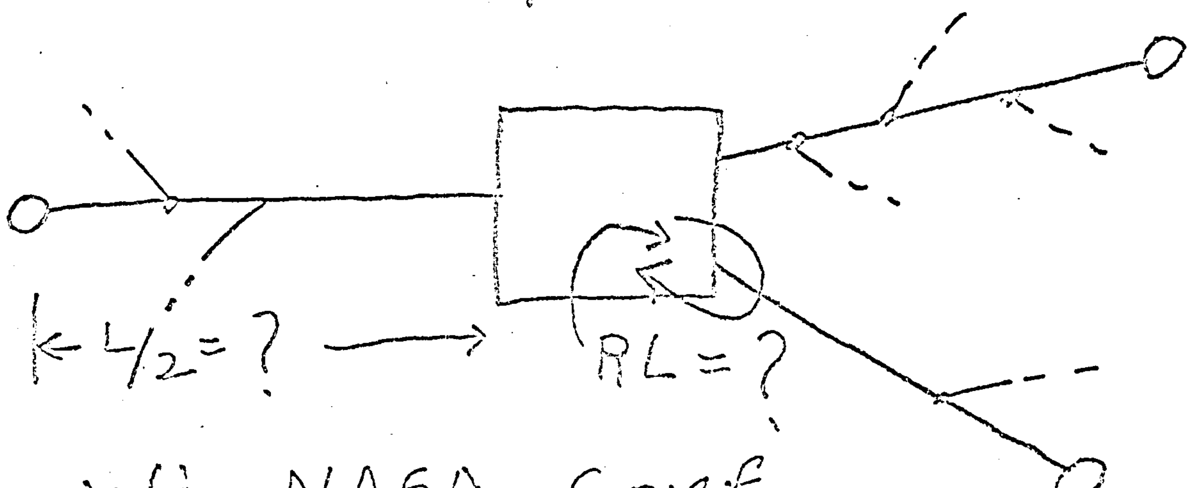
5/2/67

FIG 8



$$RL_C \cong 17 - 10\log_{10} N$$
$$\sigma = < 3 \text{ (a little)}$$

2 Wire Telephone Conf.



2 Wire NASA Conf.

May 11, 1967

ATTACHMENT C

A PLAN FOR MODIFICATION OF CERTAIN CONFERENCING ARRANGEMENTS AT KENNEDY SPACE CENTER

GENERAL

A plan has been prepared for the requested modification of the critical conference circuits at Kennedy Space Center (KSC). The plan is based on the use of a low impedance busbar arrangement for conferencing the many stations which have need to be tied together in the critical conferences. This technique has been used successfully for similar purposes in such applications as the Joint Chiefs of Staff Alerting Network, the 304 Switching Systems used at Goddard, Huntsville and Kennedy, and also at the launch complex at Point Arguello.

The objectives to be met with a modification plan included the following:

1. Eliminate the Voice Operated Switch (VOX).
2. Convert to 4-wire operation.
3. Station operation with both 2- and 4-wire conferences.
4. No change in attendant operation.
5. Automatic changeover from 2- to 4-wire operation at the station.
6. Reuse present cabling wherever possible.
7. Minimum change in station boxes.

PRESENT CABLING LAYOUT

Perhaps the best place to start in the description of the plan is by presenting a general picture of the present cabling layout. This is illustrated in Figure 1 which gives an outline of the arrangements in Launch Complex 34 (LC34). The conference circuits enter the Blockhouse from the 4-wire bridge on a 4-wire basis. At this point, each terminates in send and receive (A1A) amplifiers and a voice operated switch (VOX) which is used to convert the circuit to 2-wire operation. There are 42 of these circuits which enter the Blockhouse. The 2-wire circuits are then extended through the audio switch panel. In this unit there are keys which are used to isolate the individual conference circuits as they branch out within the complex. At these switches some of the modifications can be made which are necessary in the circuits to be converted to 4-wire operation. From the audio switch panel, the conference circuits are then carried through patch and distribution (P/D) units as indicated. Tracing one of the 42 conference circuits, this appears in the P/D unit in pin jacks which permit patching, as required, to various station branches as indicated. Each of these station branches consists of from one to about ten 2-wire stations bridged directly across the 2-wire line. Each station consists of a receiver-amplifier working into a receiver, and a microphone working through a transmitting amplifier connected to the 2-wire line as indicated. There is also a monitoring amplifier included in the station unit but, for simplicity, this has been omitted from the figure. Other station branches are connected from this and other P/D units around the complex.

The arrangements at the Automatic Ground Control Station (AGCS) are shown on Figure 1 because the audio switch panel, which is located in the AGCS building, will also provide a convenient location for mounting resistors required in connection with the conversion of the critical conference circuits to 4-wire operation. The rest of the branching-out procedure from the AGCS is the same as described previously for the Blockhouse.

CONFERENCING PLAN

A general plan and manner of cabling for the critical conference circuits is illustrated on Figure 2. There are several features in the plan:

(1) The VOX has been eliminated.

(2) The circuit is carried 4-wire from the 4-wire bridge into the Blockhouse and the AGCS and thence directly to all of the stations on the conference on a 4-wire basis.

It is not yet known whether the present A1A amplifiers have adequate power to operate with the low impedances required for use with the conference busbar. The bus amplifier B is arranged to operate with both 1 ohm input and output impedances. This amplifier provides the talk-back path from any station to all the other stations connected to the busbar. It also furnishes the sidetone path for every talking station. The receiving amplifier of every station is connected through isolating resistors to the receiving busbar. Similarly the transmitting amplifier of every station is connected through isolating resistors to the transmitting busbar. Conversations are transmitted outside the complex via amplifier A1. Conversations incoming from outside the complex are transmitted via amplifier C1. The return loss via amplifier B should be greater than 60 db.

The present 2-wire circuit can be used as the receive leg of a new 4-wire conference plan. It will be necessary to pre-empt one of the other 42 conference circuits for use as the transmit leg. In the plan illustrated, the conference circuit is fanned out from the busbar using distributing resistors for isolation purposes. As mentioned previously, there is a convenient place in the audio switch panel to mount these resistors. Additional isolating resistors can be mounted, as indicated, in the patch cords in the P/D unit. This makes it possible to isolate each of the individual station branches. The resistors could also be mounted in series with either the input or output jacks if so desired. In this plan, there is no other change required in the cabling of the individual stations which are part of each station branch. Of course it will be necessary to disconnect, in the most convenient way, those stations which have been "scrubbed" from the critical conferences.

It appears desirable to establish a second busbar in the AGCS building where the first set of isolating resistors can be mounted. If this is done, the remainder of the cabling procedure is the same as that described for the Blockhouse.

STATION TERMINAL ADDITION

The illustrated plan will permit operation with both 2- and 4-wire conferences and with automatic changeover from 2- to 4-wire, as required, with no change in attendant operation. The tests made on the amplifiers presently used in the station box indicate that they may continue to be used without change.

Figure 3 illustrates a way in which the station circuit could be modified to accommodate both 2- and 4-wire operation. It should be understood that the workability of the illustrated plan will depend upon many factors, including shock, vibration, cable leakage, cable pair balance, earth potential and other factors which may come to light later. The additions needed include 2 retard coils, 2 relays and 2 capacitors for the first 4-wire conference circuit. These are connected on the receive leg as indicated. As mentioned earlier, the present 2-wire conference leads are used for the receive leg of the 4-wire conference. One of the other 2-wire conference circuits would be employed for the transmit leg of the 4-wire conference.

Only the 4-wire conference circuits are equipped with A relays. Thus when the attendant selects a 4-wire conference, the simplex circuit connecting the A and the 4W relays is completed and these two relays operate. The -'s in the leads connecting the receive and transmit amplifiers is Bell System language indicating circuit contacts which are normally closed until the relay operates. The X's in the transmit leg are contacts indicating that the circuit is open until the relay operates and causes their closure. Therefore, when relay 4W operates, the connection is broken between the receive and transmit amplifiers and the operation of the A relay establishes the path to the new circuit obtained by disconnection of one of the 2-wire conference circuits. The capacitors are connected in the circuit to block the dc current from flowing to the other relays connected to the circuit.

Figure 4 which regroups the added equipment except for the capacitor, is mainly a redrawing of Figure 3. It illustrates the amount of equipment required for the first 4-wire conference in this plan. It also illustrates the number of leads involved in the interconnection of the station box with the new equipment which, in most cases, would probably have to be mounted externally. In addition to the leads shown, power and ground leads are also required. Where only one 4-wire conference is terminated in a box a single relay could be used, if a suitable one is available with sufficient contacts. A separate 4W relay is most desirable when more than one 4-wire conference is terminated.

To add additional 4-wire circuits to any box, it is necessary to provide an extra retard coil, an A relay, and the two blocking capacitors for each additional 4-wire circuit. Also, 4 additional leads are required for interconnection per each circuit. Of course, it is also necessary to pre-empt an additional 2-wire conference circuit to furnish the transmit leg for each of the new 4-wire circuits.

DEMONSTRATION SETUP

To illustrate the above arrangements a demonstration setup has been assembled in the laboratory. This setup includes the busbar technique discussed above. One dual station box and a single station box have been made available to us. These have been converted to permit both 4- and 2-wire operation and have been connected to the busbar conference bridge as indicated on Figure 5. Sets 1 and 2, in the dual box, are connected in parallel as part of the same station branch. Set 3 is connected on a separate station branch.

Some information has been furnished to us regarding the capacitance of the cables on the present 2-wire conference circuits. Using this we have attempted to distribute this capacitance judiciously in the demonstration circuits. Also, arrangements have been made to connect dummy loads (DL) to simulate extremely heavily loaded station branches. It is estimated that the dummy loads chosen will cause a greater loss in the circuit than any loss that would be encountered in actual practice. The demonstration will illustrate the variations in frequency response and level as the load is changed from one that is very minimal to the maximum load. We expect that the change in the ultimate system will be hardly noticeable, amounting to only a couple of dB.

It has been suggested that the conference quality could be improved if the receiver units had frequency characteristics which cut off at about 3000 Hz. Accordingly, we have connected one of the Bell System 52-type headsets to the demonstration setup to permit listening with a receiver which has the frequency response recommended.

The laboratory setup also includes means for demonstrating the 2-wire conferencing arrangements. As in the case of the 4-wire setup, a variety of loadings have been provided. In all cases, the 2-wire circuit is terminated with 600 ohms and provision has been made for adding a capacitor equivalent to reasonably heavy cabling, and additionally, for station loadings of 50 and 350 conferees.

TRANSMISSION CONSIDERATIONS

Measurements of the transmitting amplifier and microphones indicate that the output level of the transmitting amplifier from an average talker is about -28VU.* On a 2-wire circuit, since the transmitting amplifier is connected directly to the receiving amplifier, the level at the input to the latter will also be -28VU. In the case of the 4-wire circuit, the transmission loss through the busbar has been arranged to be 0 dB. The level at the receiver will therefore also be -28VU in the case of the 4-wire circuit. Thus both the 2-wire and 4-wire circuits will be operating at the same point on the AGC curve of the receiving amplifier. That is about 4 dB below the knee of the curve.

It should be pointed out at this time that in our normal treatment of private line service we usually use a speech input level about 15 dB higher than the -28VU applied to

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* Measured into 600 ohms.

these circuits. This is done to obtain a good signal-to-noise relation. If a new microphone were used, it could very well be possible to achieve this improved speech level.

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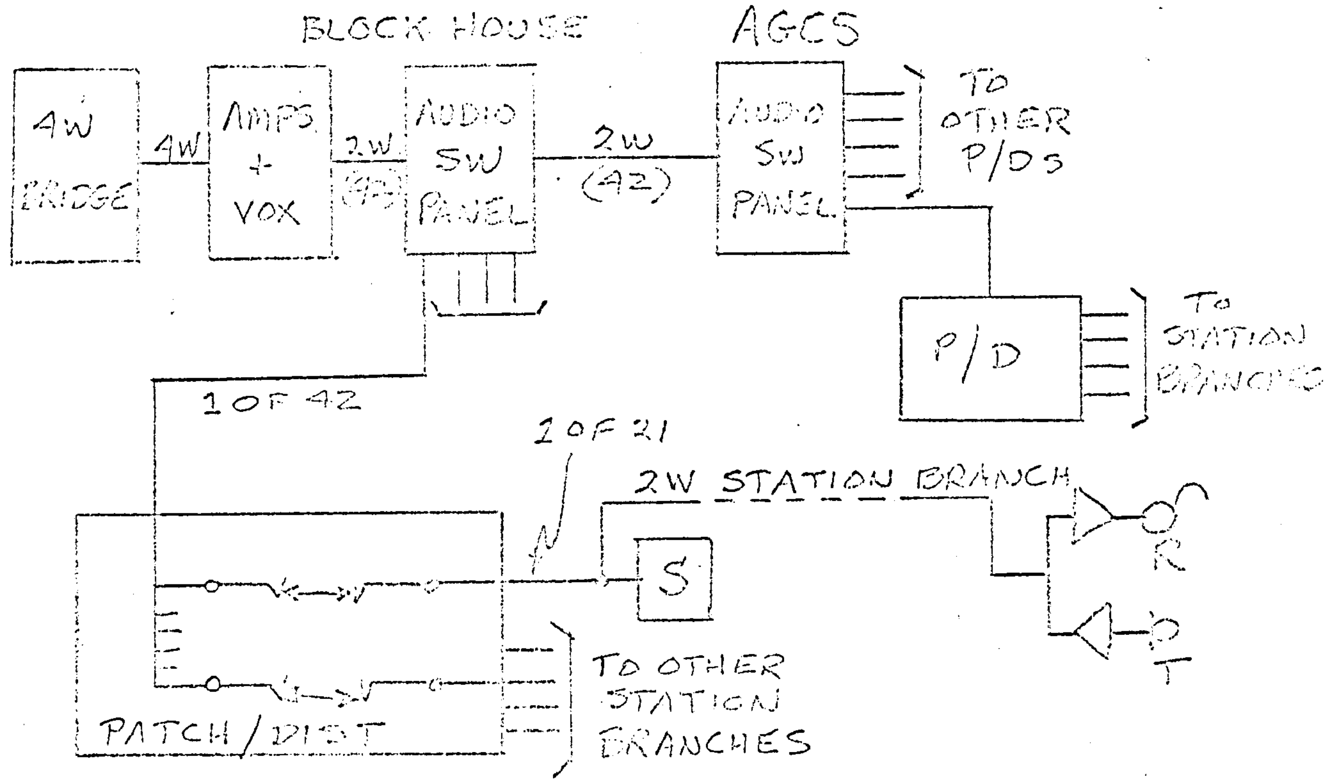

PRESENT CABLING LAYOUT

FIGURE 1

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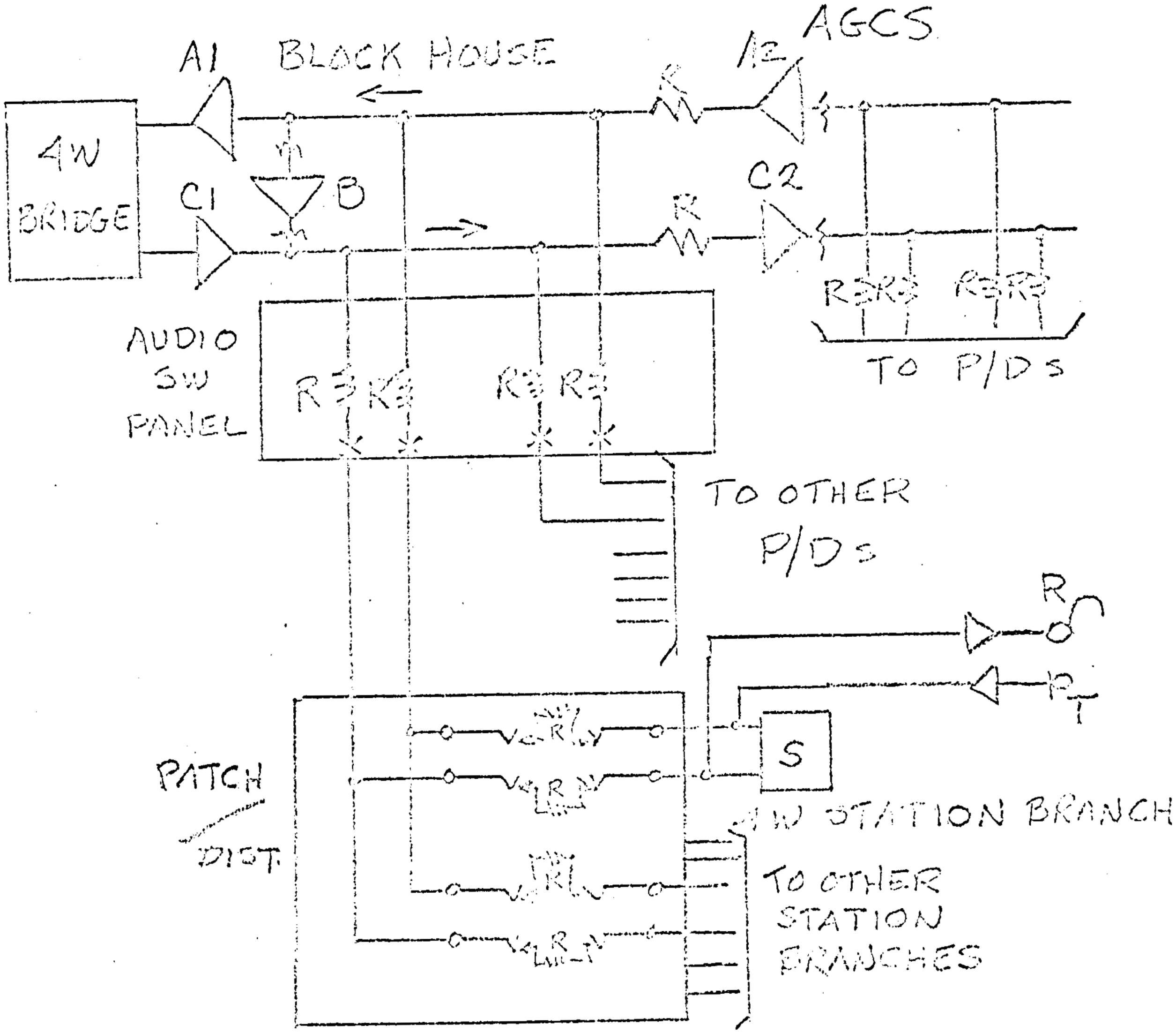

FIGURE 2

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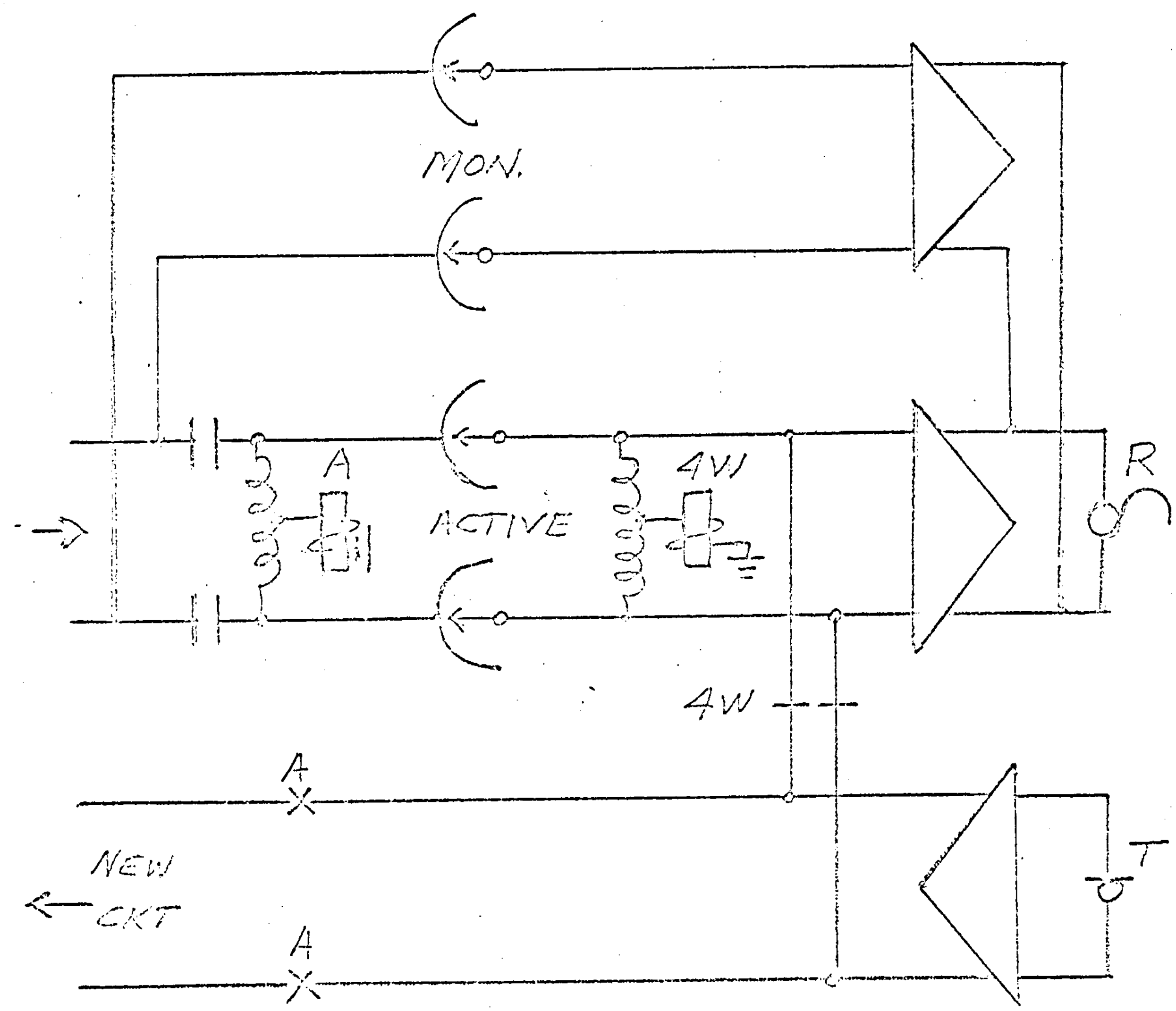

STATION TERMINAL ADDITION

FIGURE 3

4/25/67 HJH

STATION ADDITION SEPARATION

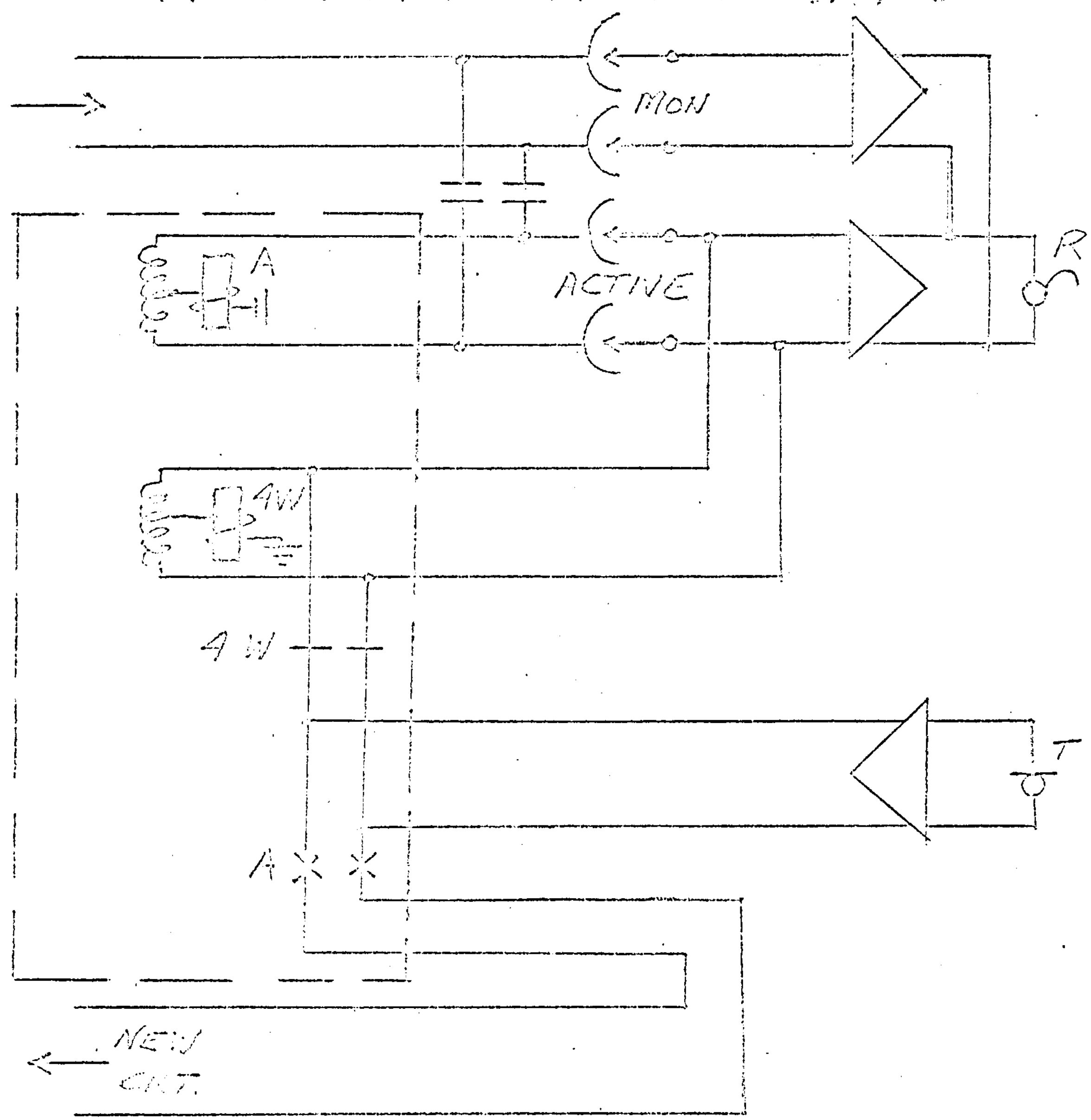

FIGURE 4   4/25/67 HJM

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DEMONSTRATION SET-UP

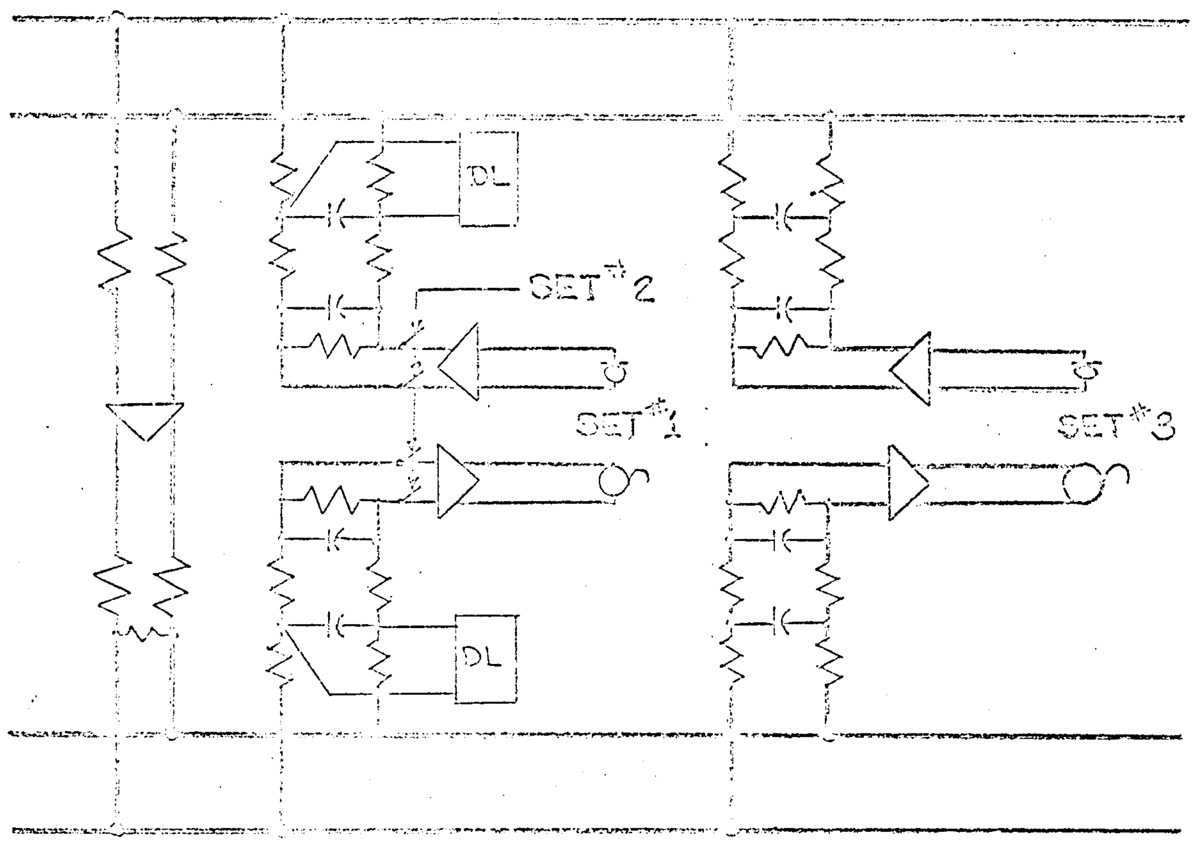

FIGURE 5

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BELLCOMM, INC.

Subject: Oral Report by Bell Telephone Laboratories on the Addition of 4-Wire Circuits To The Operational Intercommunication System at KSC

From: J. J. Hibbert
G. H. Speake

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